Micro-Mirror Array Surface Roughness Specification

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Abstract:

A specification for the rms surface roughness of the individual micro-mirror array facets is derived. The primary effects considered are:

- the wavelength dependent total integrated scatter from each facet, based on its rms surface roughness
- the fraction of scatter relayed by the f/24 collimator into the spectrometer
- the relative field size of "off" versus "on" facets
- the contrast requirement

Discussion:

When the mirror facets of the micro-mirror array (MMA) are illuminated by the f/24 beam from the NGST optical telescope assembly (OTA), the "on" facets send light into the rest of the spectrometer optics, while the "off" facets send light to a beam stop. However, some fraction of light is scattered from the "off" facets. A portion of this is captured by the spectrometer optics and serves to reduce the contrast in the spectral image.

For a facet of rms surface roughness σ (measured in nm), the total integrated scatter (TIS) is the fraction of input energy scattered into the hemisphere ($\Omega = 2\pi$ sr):

$$TIS = \left(\frac{4ps}{l} \right)^2 \qquad \text{or} \qquad s = \frac{l\sqrt{TIS}}{4p}$$

The solid angle of acceptance of the f/24 collimator is a small fraction of a hemisphere:

$$\Omega = p\left(\frac{1}{2f/\#} \right)^2 = 0.00136\,sr$$

If we assume a 3x3 grid of facets is turned "on" for a compact source, then there are ~1800x1800 facets in the "off" position contributing scatter. This is a ratio of 360,000. If the required contrast for the On/Off energy is C, and if the MMA is uniformly illuminated, then the scatter requirement can be written as:

$$TIS \cdot \frac{0.00136}{2p} \cdot 360{,}000 < \frac{1}{C}$$

Example:

So, for $\lambda = 1$ μm and a required contrast of C = 300, we must have TIS < $4.28\ 10^{-5}$. This requirment implies a facet rms surface roughness $\sigma < 0.52$ nm.